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DISTRIBUTION OF BLACK STAIN ROOT DISEASE IN CALIFORNIA

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ABSTRACT

Black stain root disease, caused by Ceratocystis wageneri, is described and discussed. The disease affects principally four species of conifers in California: ponderosa pine, Jeffrey pine, singleleaf pinyon pine, and Douglas-fir. The distribution of the disease in the state is given for each host. The disease was found throughout the range of Douglas-fir, in the northern and central Sierra Nevada and the Cascades in yellow pines, and in the San Bernardino, White, and southern Sierra Nevada mountains in singleleaf pinyon pine. The majority of infection centers observed in Douglas-fir were small and involved sapling and pole-size trees in natural stands. Centers were on average to good sites that had been "disturbed" by roads, skid trails, campsites, etc. Management alternatives that might mitigate the impact of the disease in Douglas-fir are discussed.

INTRODUCTION

Black stain root disease in California was described in 1938 based on observations of dying ponderosa pine (Pinus ponderosa) and Jeffrey pine (P. jeffreyi) on Blacks Mountain Experimental Forest, Lassen County, California (11). The causal fungus, Verticicladiella wagenerii, was described and named by Kendrick (8). It had been identified as a pathogen only of pines in the western United States (including ponderosa, Jeffrey, singleleaf pinyon (P. monophylla), and pinyon (P. edulis) pines (11); and lodgepole (P. contorta) and eastern white (P. strobus) pines (9)) until 1965 when the fungus was isolated from Douglas-fir (Pseudotsuga menziesii) in California (3). Several additional tree species have been rarely infected in California, including sugar pine (Pinus lambertiana), knobcone pine (P. attenuata), and western white pine (P. monticola) (2).

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Because of increasing concern about this disease, especially as it affects the management of second-growth Douglas-fir, observations have been made to define its distribution and characteristics. The purpose of this report is to 1) discuss existing knowledge of the biology of the disease and its causal organism, 2) provide the known distribution of the disease in California, and 3) present silvicultural alternatives that may mitigate the effects of the disease on Douglas-fir management goals and objectives. This report is concerned principally with the disease in Douglas-fir, although research information available from ponderosa pine is included. For more complete information on the disease in ponderosa pine consult Byler et al. (1).

BIOLOGY AND ECOLOGY

The sexual state of the fungus has been reported and described on ponderosa pine as Ceratocystis wageneri Goheen and Cobb (5). Prior to that report only the asexual state, V. wageneri, was known. The fruiting bodies of both states have been located in the galleries of subcortical, root-feeding insects (principally Hylastes macer LeConte) in ponderosa pine (5).

Pathogenicity tests and seedling inoculations have indicated no host specificity of isolates of the fungus (3, 10). However, field observations suggest that the fungus is restricted to one species group even in a mixed species stand. Recent studies have discovered that several "strains" of the fungus may exist (personal communication, Harrington and Cobb). In California, three "strains" appear to be present that may be relatively host specific. This includes one on the pinyons, a second on Douglas-fir, and a third strain on ponderosa, Jeffrey, and lodgepole pines.

The fungus appears to spread two ways: local transmission between trees, and overland, "long-distance" spread. Initiation of disease foci probably occurs when spore-carrying bark beetles invade tree roots. The principal vector of the fungus in ponderosa pine may be H. macer (5). The possible vectors in Douglas-fir have not been identified, but several insects have been implicated, including species of Pseudohylesinus and/or Hylastes.

After establishment of the fungus, local underground transmission through the root systems occurs. Between - tree transmission may be through root contacts or, more likely, fungus growth through the soil for short distances and direct infection of small feeder roots (4). The rate of local underground spread in a ponderosa pine stand is highly variable and dependent on species composition, density, and site, although the average annual radial spread was 4 feet (range 0 to 20 feet) at Georgetown Divide, El Dorado County (1). The rate and method of underground transmission of the disease in Douglas-fir is not known.

Once established in a living tree, the fungus is limited to the xylem tissue of the roots and bole. The amber hyphae grow within the tracheids and do not enter parenchymatous cells, either ray or longitudinal. Growth between cells occurs through the bordered pit pairs without any penetration

of the cell wall (10). This restricted growth results in the diagnostic brown to black stain observed in infected trees. The stain occurs as arcs in the wood that correspond with the annual rings. The stain may occupy very little to most of the circumference of the tree and may be from one to many annual rings deep.

Infected trees undergo gradual to rapid crown decline prior to mortality. Crown symptoms can include reduced terminal growth, yellowing and premature loss of foliage, and needle shortening. A heavy cone crop may also be present in trees pole-size and larger. Infected trees are likely to be successfully attacked and killed by bark beetles (1, 6).

Very little information is available on stand and site characteristics associated with the disease. Surveys of infected ponderosa pine on the Georgetown Divide related incidence of the disease with stand species composition and stand density. Pure or predominant ponderosa pine stands with moderate to high stand densities had a higher probability of being infected (1). Elevational limits (between 4000 and 5000 feet) of the disease were also revealed. A characteristic of the disease in Douglas-fir is its higher incidence along roads (7) and the tendency to identify it in young plantations or dense natural regeneration (6).

A question of considerable importance that remains unanswered is the probability of initiation of the disease in a stand after thinning operations. Management of second-growth Douglas-fir in the coastal counties of California is increasing in importance. The high productivity of the land and the potentially high rate of economic return encourage intensive forest management, including precommercial and commercial thinnings. Black stain root disease, however, has been observed in stands following thinning. It is not known if the disease was present prior to thinning. If a correlation between disease incidence and thinning does exist, substantial losses in future productivity could occur. On the other hand, densely stocked stands may also be conducive to infection, resulting in the need for some form of stocking control.

DISEASE DISTRIBUTION

Locations of black stain root disease in California were determined by a variety of methods. Reports of the disease were collected from existing records and from inquiries made of forest pathologists in the state. Reports on location of the disease were solicited from field personnel in both the public and private sectors. Additional locations were discovered through informal surveys and observations by State and Federal pest specialists.

In Douglas-fir, a total of 62 areas, each consisting of one or more centers, were identified in the Coast Range, Cascade Range, and Sierra Nevada. Twenty areas of infection were identified in the yellow pines in the Cascades and Sierra Nevada. The number of infected locations in singleleaf pinyon pine was more limited - only three - but these were widely dispersed, having been found in the San Bernardino Mountains, Sierra Nevada, and White Mountains (Figure 1).

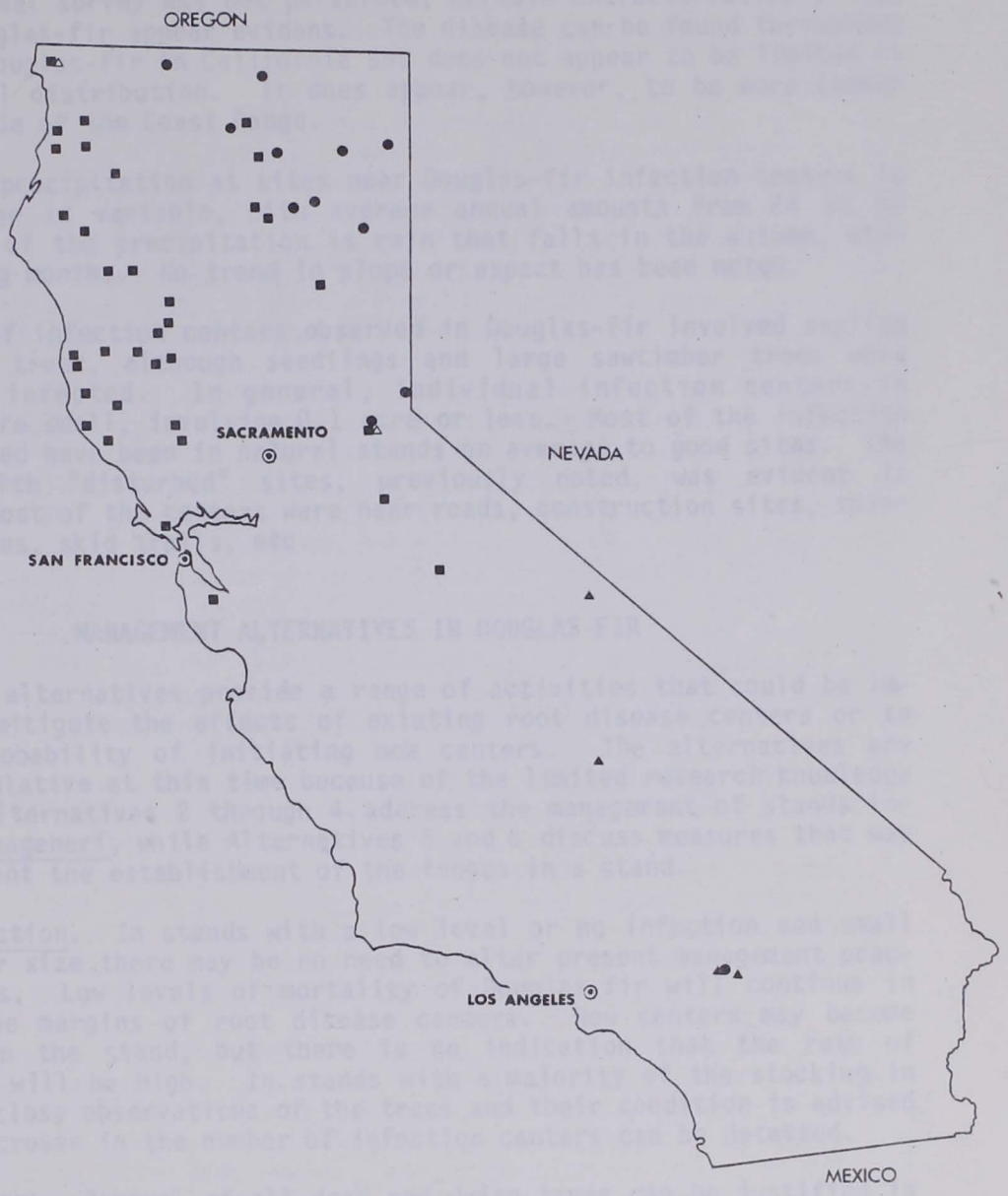

Figure 1. Distribution of black stain root disease, caused by Ceratocystis wageneri, in California. Each symbol represents one or more infection centers involving a particular host (■ = Pseudotsuga menziesii; ● = Pinus ponderosa or P. jeffreyi; ▲ = P. monophylla; △ = P. lambertiana or P. attenuata).

Although a formal survey was not performed, certain characteristics of the disease in Douglas-fir appear evident. The disease can be found throughout the range of Douglas-fir in California and does not appear to be limited in its elevational distribution. It does appear, however, to be more common on the west side of the Coast Range.

The amount of precipitation at sites near Douglas-fir infection centers in the Coast Range is variable, with average annual amounts from 24 to 93 inches. Most of the precipitation is rain that falls in the autumn, winter, and spring months. No trend in slope or aspect has been noted.

The majority of infection centers observed in Douglas-fir involved sapling and pole-size trees, although seedlings and large sawtimber trees were occasionally infected. In general, individual infection centers in Douglas-fir were small, involving 0.1 acre or less. Most of the infection centers observed have been in natural stands on average to good sites. The association with "disturbed" sites, previously noted, was evident in California. Most of the centers were near roads, construction sites, thinnings, campsites, skid trails, etc.

MANAGEMENT ALTERNATIVES IN DOUGLAS-FIR

The following alternatives provide a range of activities that could be implemented to mitigate the effects of existing root disease centers or to reduce the probability of initiating new centers. The alternatives are somewhat speculative at this time because of the limited research knowledge available. Alternatives 2 through 4 address the management of stands infected by C. wageneri, while Alternatives 5 and 6 discuss measures that may limit or prevent the establishment of the fungus in a stand.

1. No Action. In stands with a low level or no infection and small disease center size there may be no need to alter present management practices or plans. Low levels of mortality of Douglas-fir will continue in and around the margins of root disease centers. New centers may become established in the stand, but there is no indication that the rate of establishment will be high. In stands with a majority of the stocking in Douglas-fir, close observations of the trees and their condition is advised so that an increase in the number of infection centers can be detected.

2. Salvage. Removal of all dead and dying trees can be justified in certain situations. When a stand is infested with black stain root disease there will be groups of dead trees that may or may not be of a commercial size and be accessible. Several problems arise when planning salvage operations in root disease centers. First, mortality is recurrent and salvage must be accepted as a routine operation. An optimum reentry time must be determined that balances the value of the dead and dying timber and the cost of the operation with the anticipated rate of future mortality and the rate of deterioration and reduction in utilization of the dead timber. Second, this disease appears to be more active in the smaller size classes, thereby limiting the amount of merchantable volume available. The impact of both of these problems can be reduced by a very careful selection of trees for marking around disease centers and removing those that have early indications of crown decline. A third concern with salvage operations is

they have no effect on the disease and future mortality. The amount of mortality and area out of production will be the same with or without a salvage operation.

If all Douglas-fir within a center were felled during a salvage operation, then the time the area is out of production to Douglas-fir would be reduced. The fungus is expected to die out sooner within a center that lacks living hosts, but it would remain active around the margin and continue to spread as long as hosts are available. Replanting the area with Douglas-fir, even after an appropriate wait (suspected to be 7 to 10 years), could reintroduce the fungus into the center from the margin if root contacts are made between infected roots and those of the regeneration.

3. Patch Cut. This alternative attempts to maximize the return on a salvage operation, as well as reduce the future impact of the disease. The first step is to identify all root disease centers and their margins, based on crown and bole or root symptoms. In addition to marking all of the host trees in the center, a buffer strip of 75 feet beyond the margin encircling each center should be marked, including all host trees. All Douglas-fir within the confines of the outer margin of the buffer must be felled. The intent is to remove all susceptible host tissue from the reaches of the fungus. The buffer strip should limit underground spread of the fungus into the surrounding healthy stand. By leaving the centers clear of host trees for seven to ten years the land could then be put back into production of the host. Otherwise, non-host trees should be regenerated.

4. Regeneration. Care must be exercised whenever black stain root disease centers are regenerated. Regeneration of active centers with a susceptible host species will be unsuccessful. If the objective is to return the land to production of Douglas-fir, then at least a seven- to ten-year wait after removal of all the hosts must occur. Alternative, non-host species can be regenerated at any time. If salvage is the only operation and the fungus persists around the margin of centers, then the area should not be artificially regenerated with Douglas-fir.

5. Thinning. Thinning densely stocked, precommercial-size stands of Douglas-fir can improve the growth and vigor of residual trees. This may reduce the susceptibility of living hosts to the vectors of the fungus and reduce the probability of initiating new disease centers. However, the thinning operation, site disturbance, and production of dying stumps and roots could encourage the activity of vectors and increase the likelihood of infection. The impact of the latter might be reduced if the thinning is done when the stand is young (<10 years) and the stocking level is reduced below what would normally be acceptable. This may be beneficial for several reasons. First, the root systems will be small and the number of root contacts limited, thereby reducing the spread of the fungus, if established. Second, the small roots may limit the number of attacks and brood production by the vectors. Third, by thinning heavily the need for additional thinnings will be reduced, thus limiting the number of future entries that may be conducive to the initiation of new centers.

An early, heavy thinning does have several drawbacks. Opening up the site will increase the problem with competing vegetation, especially in the North Coast area, for several years until the trees regain full site occupancy. This will require a commitment for vegetation management. Also, an open stand produces trees that more slowly prune themselves, resulting in potentially lower-quality wood at harvest. Third, total cubic volume during the rotation will be reduced because of the lack of full site occupancy during the early years. Lastly, if losses do occur later in the rotation, the stand may become understocked and not achieve its optimum productivity.

6. Regeneration Planning. To reduce the need for thinning, regeneration of clearcuts may be adjusted so that the number of surviving seedlings more closely approximates the desired number of stems in the stand at a later date. This will reduce the number of thinnings and, hopefully, reduce the initiation of black stain root disease centers. Also, mixtures of non-host species with the host species can be encouraged.

This alternative is of considerable risk. The percent seedling survival, and early plantation success must be accurately estimated if the correct number of seedlings is to be planted. The problem of competing vegetation discussed in Alternative 5 will be of equal or greater importance, as will the self-pruning problem. The option of selecting the best crop trees, during a precommercial thinning will be eliminated, so that trees of poor form or with poor characteristics will have to be tolerated until at least the first commercial thinning. The loss of individual stems could result in sizable openings in the stand. Overall, the risk of understocking and lost productivity will be considerable.

DISCUSSION

Statewide, black stain root disease ranks as a minor forest pest on commercial forest lands of Federal ownership. A survey of northern California estimated that this pest was involved in the death of 14,000 trees (< 1 percent of the total mortality) during the year prior to June 1978. The estimated gross merchantable volume lost during this period was 5.6 MMBF (Scribner), also less than 1 percent of the total mortality. This survey information represents a land base of 6.3 million acres, thereby, diluting the impact of a disease of scattered occurrence.

Locally, by contrast, black stain root disease can be important where individual stand management is the concern. The presence of this disease, or the threat of its initiation, can alter the stand management prescription, resulting in lost or relinquished resource productivity. We have already observed several areas in the state where the disease is of considerable importance and its presence has resulted in significant management changes. Also, the threat of the disease in some areas has caused hesitancy in stand management activities. At this time, it is not known what the potential for damage by this fungus is in managed forest stands.

The level of knowledge about this disease and its causal organism is quite limited and is the major stumbling block to developing dependable, assured management alternatives. Considerable research is necessary in many areas, including the biology and ecology of the fungus; identification of the vectors, if any, and their role in fungus transmission; the initiation of root disease centers and the mechanism of underground spread following establishment; longevity of the fungus in host tissue and soil; and site and stand characteristics related with the disease. Until answers to these questions begin to accumulate, any management alternatives that are prescribed are tentative and speculative.

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Enclosure